the lower levels is not accumulative, but instead becomes less and less with increasing altitude. In general the percentage of error in the computed velocities is practically the same as that in the assumed altitudes. This is true, however, only when the percentage of error in the assumed altitudes does not change materially from minute to minute as is the case in the higher levels.

Special efforts have been made to determine to what altitude our balloons will ascend. As a rule the observations that reached considerable altitudes ended because of the bursting of balloons, or disappearance on account of distance, haziness or clouds. No cases were found where there was convincing evidence that the balloon reached a state of equilibrium and floated. This is not in accord with the results obtained by British investigators.[6] Our conclusions are based on more than 800 two-theodolite observations, of which more than 50 reached above 10,000 meters in altitude and 1 to an altitude of approximately 15,500 meters.

CONCLUSIONS

1. Although the ascensional rate of balloons is not constant, as has been assumed, there is striking agreement between the assumed and actual heights up to moderate altitudes. In the higher levels the agreement is not so close, however. At an altitude of 15,000 meters the assumed height is approximately 5 per cent below the actual altitude.
2. In individual observations the actual heights at about the 2,000-meter level are within 10 per cent of the assumed in approximately three-fourths of the cases. Observations taken in the early morning hours before convection sets in are within 10 per cent of correct in practically all cases.
3. At moderate heights from 2,000 to 10,000 meters the accuracy is still greater, since convection is absent and the balloons ascend at essentially a constant rate very close, as a rule, to the assumed rate.
4. Convection appreciably affects the ascensional rate only in the lower levels—below 1,500 or 2,000 meters. The effects are negligible in the early morning hours.
5. The balloons continue to ascend at the ordinary rate until they either burst, or disappear on account of distance, cloudiness, etc. No cases were found in which the balloon reached a state of equilibrium and floated. It is worthy of note also that only two or three balloons showed evidence of a slow leak caused by pinholes.
6. As to what takes place above 16,000 meters, we have at present no information. It seems likely, though, that the best balloons continue to rise to perhaps 20,000 meters or more, and that the rate of ascent continues to increase.

Acknowledgment is due to Mr. W. R. Gregg for valuable suggestions and to Mr. Edgar W. Woolard for aid in the mathematical portion of the paper.

551.574 (794)

THE PROBABILITY OF CERTAIN MINIMUM TEMPERATURES IN THE SANTA CLARA VALLEY, CALIFORNIA IN SPRING

By ESEK S. NICHOLS, Meteorologist

[Weather Bureau Office, San Jose, California, March 15, 1924]

The average daily minimum temperature, based on 17-years' records at the Weather Bureau office in San Jose, Calif., is 42.1° for the month of March, 43.7° for April, and 45.9° for May. The lowest recorded in March during the entire period is 30°; in April, 33°; and in May, 35°. On the average, less than 1 day per year in March has a minimum of 32° or lower, tenths of a degree considered; and that minimum has not been reached on any day in April or May during the 17-year period. The average date of the last killing, or very severe frost in spring is February 11; and the latest is March 31. However, frosts of less severity, sometimes sufficient to damage tender vegetation considerably, occur in April and May. Some frost occurs in May in nearly one-half of the years.

The above paragraph contains such minimum temperature and frost data as are usually given in climatological articles. For many purposes, notably in connection with studies of damage to fruit by low temperatures and protection from such damage, more detailed knowledge of the occurrence of low temperatures of different degrees is desired; not only for San Jose but also for other places in the Santa Clara Valley, particularly in the colder sections thereof. This article is written for the purpose of supplying such additional information. Also, a method of increasing the usefulness of a short temperature record taken near a station having a long record is illustrated.

FREQUENCIES OF CERTAIN TEMPERATURES AT SAN JOSE

The first step taken in this study was to determine the number of days in the first half of March (1st to 15th, inclusive) throughout the 17 years of record at San Jose having each minimum temperature from the lowest recorded up to 45°, in whole degree intervals. Then beginning with the lowest, progressive sums were taken, so as to show the total number of days on which the thermometer fell to or below each temperature considered. Dividing these sums by 17, carrying the divisions to tenths, gives the numbers in the second column of Table 1, the average numbers of days during the first half of March with each minimum temperature or lower. Thus, there is an average of 0.1 day per year, or 1 day in 10 years, with a minimum of 30° or lower in the first half of March; with 32° or lower the number is 0.8, or 8 days in 10 years. Similar data were obtained for the second half of March (16th to 31st, inclusive), the two halves of April, and the first 15 days of May, all of which figures are entered in the third and subsequent columns of Table 1.

Figure No. 1 is a line diagram on which have been plotted the data from Table 1, minimum temperatures in degrees as abscissas and average numbers of occurrences as ordinates. For each of the five semimonthly periods considered the resulting curve is roughly a parabola with axis vertical; showing that, for the lowest temperatures in each case, especially the first three or four, increase of frequency with increase of temperature is slower than it is for higher temperatures. Thus, for the fore part of April, increase of frequency from 37° to 38° is much greater than the increase from 33° to 34°. Also, the lower portions of the curves for April, and to a lesser degree that for the latter part of March, are crowded together; showing a comparatively slow decrease in the frequency of very cold days as the season advances. Thus, temperatures of 35° or lower are nearly as numerous in the latter part of April as they are in the first half of that month; and 33° or lower occurs nearly as often in the first half of April as in the second half of March.

[6] Johnson, N. K., Quar. Jour. Roy. Met'l Soc., Vol. XLVII, p. 49.

MINIMUM TEMPERATURE RECORDS IN ORCHARD DISTRICTS

To determine temperatures in orchard districts, particularly minima, special stations have been maintained at a number of places in the Santa Clara Valley during the springs of 1922 and 1923. The period of observation is not sufficiently long to enable us to find directly the frequencies of various temperatures throughout the valley as we have done in the case of San Jose. But we may compute the probable frequency numbers by an indirect method, which is followed below.

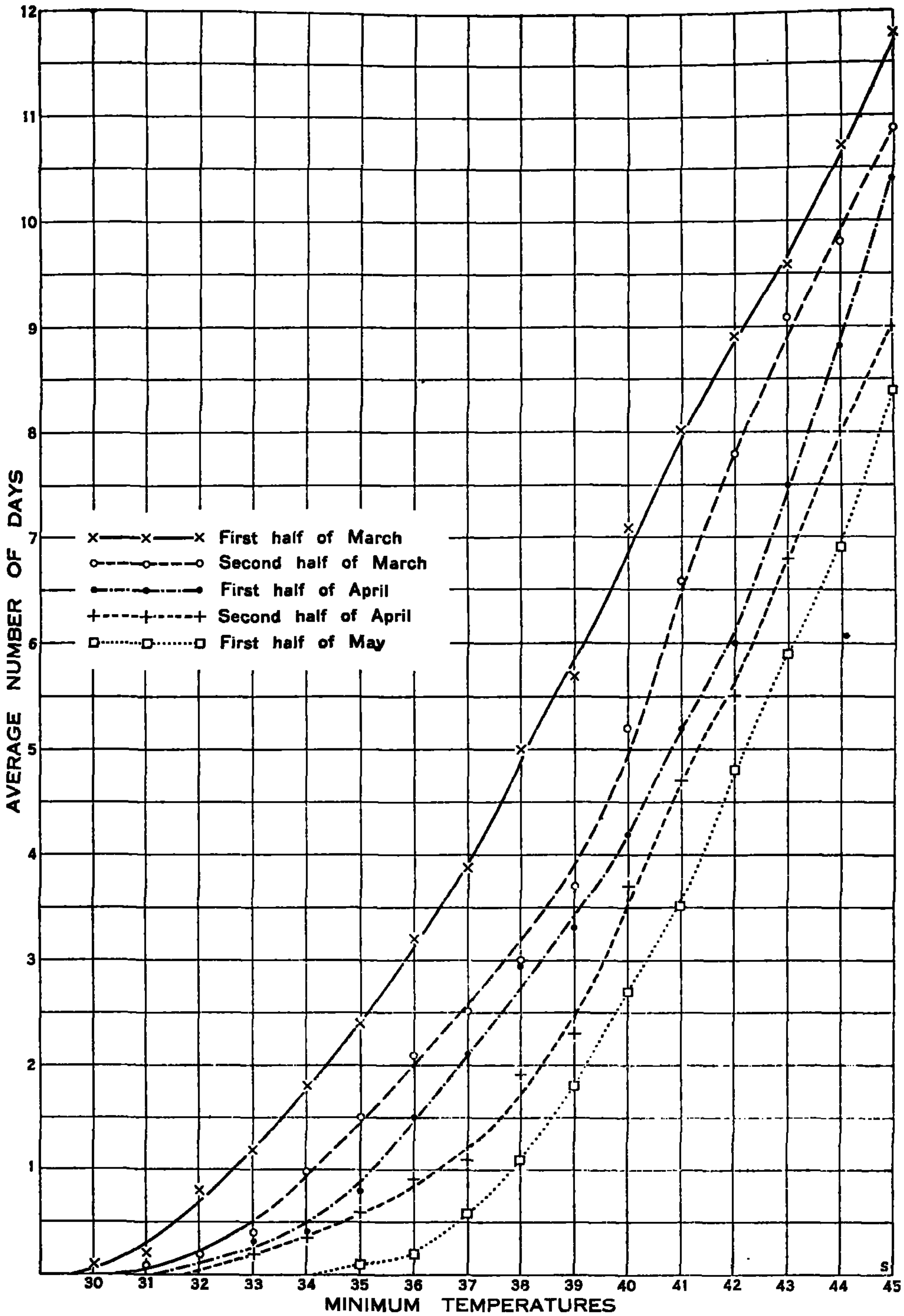

FIG. 1.—Average number of days with certain minimum temperatures during certain periods in spring, San Jose, Calif.

RELATIONS BETWEEN MINIMUM TEMPERATURES AT SAN JOSE AND THOSE AT SUBSTATIONS

Considering, in general, only mornings on which the San Jose minimum was 40° or lower, from March 1 to May 15 of 1922 and 1923, the two springs with substation records, I subtracted each minimum for each substation from the corresponding data for San Jose. In Table 2 are entered, for each station, numbers of cases in which the differences were positive, negative, and zero, the sums of both the positive and the negative differences separately, the average difference, and the highest and lowest differences.

The first 14 stations listed in this table were in operation during both springs of record. Following are 6 additional stations that were maintained during only one season, or a portion thereof; means are of course not so reliable as in the cases of the longer records. Also, at the bottom of the table are data for three cooperating stations located in orchard districts and equipped with the ordinary louvered shelters. The relative locations of the stations are shown on the accompanying map, Figure 2. Also, their altitudes above sea level, taken generally from U. S. Geological Survey topographic maps, are given in Table 2; and a brief description of the topography of the district is contained in my paper entitled "Climate of San Jose, California."* In all except two stations, one on each side of the valley in the foothills, the mean and the most frequent differences are negative; that is, the low minimum temperatures at the time of year we are considering average and are usually lower at the outside stations than at San Jose. Also, differences for the several stations vary considerably. Several reasons may be mentioned as accounting for these differences, especially the following: Topography; distance from San Francisco Bay; the fact that the San Jose thermometers are exposed at a height of 12 feet above ground, whereas the others are at about the 5-foot elevation; the slight effect of the city in raising the minimum at the central station; and the fact that the special station thermometers were exposed in shelters of somewhat more open type than those at San Jose and the three stations listed at the bottom of Table 2.

Further, I plotted on cross-section paper the relations between San Jose minimum temperature and the sub-

*"Climate of San Jose, California," MONTHLY WEATHER REV., October, 1923, 51:509-515.

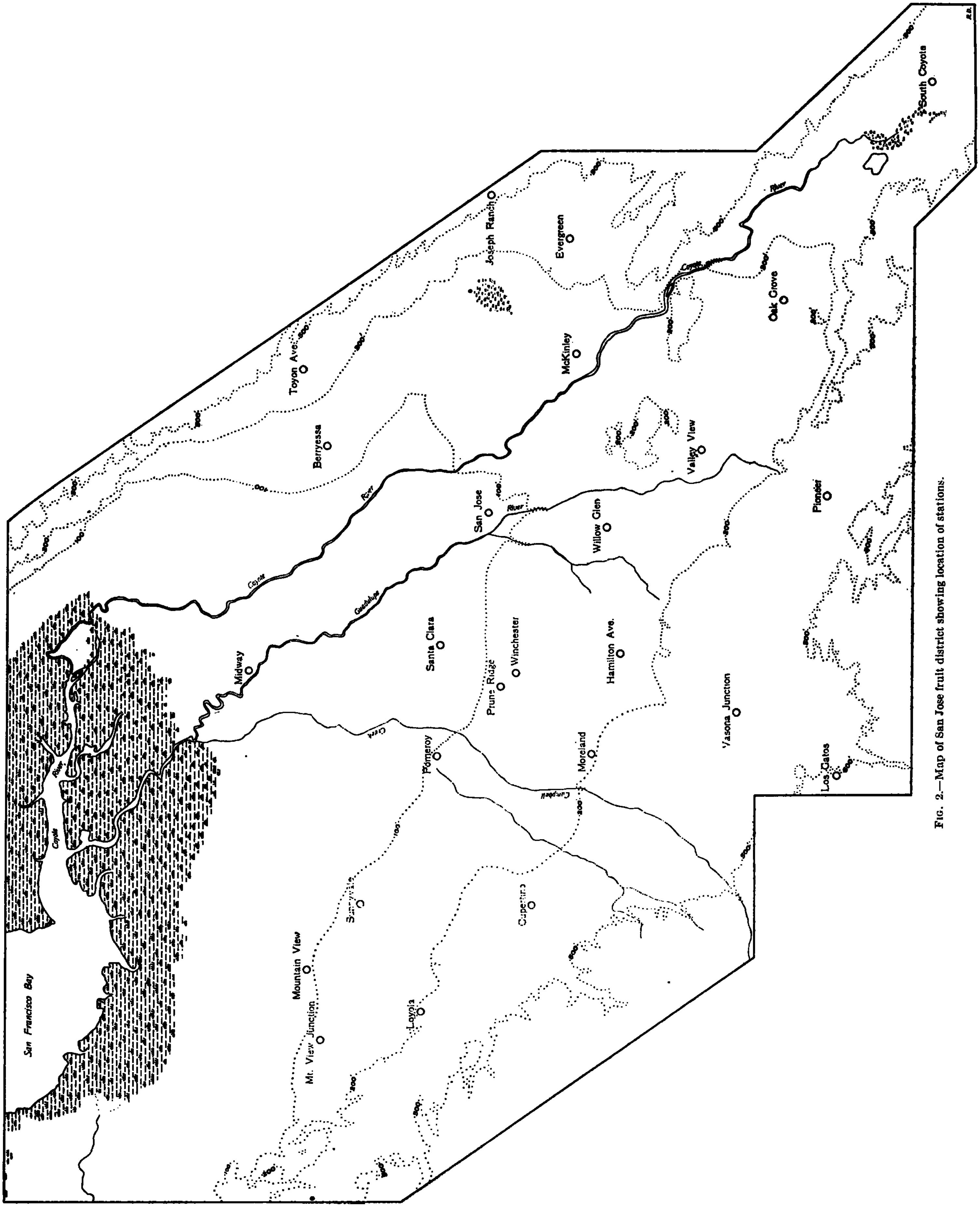

FIG. 2.—Map of San Jose fruit district showing location of stations.

station differences for the cases used in working up Table 2, minimum temperatures as abscissas and differences as ordinates, one chart for each station, and drew free-hand lines of best fit. These dot charts show a general tendency toward decrease of difference and decrease in variability of difference with decrease of minimum temperature. (Charts not included herewith, for lack of space).

PROBABILITY OF LOW MINIMUM TEMPERATURES AT SUBSTATIONS

Now, if a certain minimum temperature at San Jose is, on the average, accompanied by a minimum a certain number of degrees lower at a given substation in the vicinity, this lower temperature is approximately as frequent at the substation as the higher temperature is at San Jose. We may, then, use the San Jose frequency curves of Figure 1 to determine the frequencies at the substation by applying the proper mean difference, from Table 2, to the numbering of the temperature lines of the figure. Or, better, the difference to be applied may be modified in accordance with the dot-chart of differences for the particular substation considered. This method has been followed in obtaining the probable frequency of each low temperature at each station listed in Table 1 during the five semimonthly periods considered herein. Results are entered in Table 3 after multiplying the frequency numbers by 10 to show the probabilities during a decade.

USE OF RESULTS

From Table 3 an orchardist located in the vicinity of one of our stations may decide whether it will pay him to prepare to protect his fruit from damage by low temperatures in spring. For instance, if he lives at Loyola and he knows that his fruit will not be in a condition to be damaged by a temperature of 31° until after the middle of March, our table shows that such temperature is so infrequent that it would not pay him to prepare. But if he lives at Willow Glen and his fruit would be seriously injured by 28° after the middle of March it would probably pay him to install orchard-heating equipment.

The difference data of Table 2 and the substation difference charts are of inestimable value in forecasting minimum temperatures in the valley. According to the method used the San Jose minimum is estimated first, then the probable substation minima are predicted. The charts are particularly useful; for from them the forecaster can obtain not only the probable difference, but also, by noting the relative scattering of the dots at the several stations and in the part of the temperature scale in use at any particular time, the dependence that may be placed upon the estimated differences.

Although the period of substation record used covers only two seasons in any case, it is believed by the writer that increased amount of data will not change the probable frequency number greatly; for by the method used the short substation record has been connected up with a record of considerable length made in the immediate vicinity.

TABLE 1.—*Frequencies of certain minimum temperatures in spring at San Jose, Calif.*

Minimum temperatures	Average number of days yearly with given minimum temperature in— First half March	Second half March	First half April	Second half April	First half May
30° or lower	0.1	0	0	0	0
31° or lower	0.2	0.1	0	0	0
32° or lower	0.8	0.2	0	0	0
33° or lower	1.2	0.4	0.3	0.2	0
34° or lower	1.8	1.0	0.4	0.4	0
35° or lower	2.4	1.5	0.8	0.6	0.1
36° or lower	3.2	2.1	1.5	0.9	0.2
37° or lower	3.9	2.5	2.1	1.1	0.6
38° or lower	5.0	3.0	3.0	1.9	1.1
39° or lower	5.7	3.7	3.3	2.3	1.8
40° or lower	7.1	5.2	4.2	3.7	2.7
41° or lower	8.0	6.6	5.2	4.7	3.5
42° or lower	8.9	7.8	6.0	5.5	4.8
43° or lower	9.6	9.1	7.5	6.8	5.9
44° or lower	10.7	9.8	8.8	8.0	7.4
45° or lower	11.8	10.9	10.4	9.5	8.9

TABLE 2.—*Differences between minimum temperatures at San Jose and corresponding minima at substations on certain dates in 1922 and 1923*

Stations	Altitudes, feet above sea level	Number of cases +	Number of cases −	Number of cases 0	Total differences +	Total differences −	Mean differences	Range of differences Highest	Range of differences Lowest
San Jose	95								
Berryessa	125	0	60	1	0	189	−3.1	0	−7
Toyon Avenue	250	16	29	16	43.5	72	−0.5	+8	−7
Evergreen	235	4	55	2	45	208	−3.3	+2.5	−11
McKinley	155	0	60	1	0	287	−4.7	0	−12
Oak Grove	185	0	60	1	0	301	−4.9	0	−14.5
Valley View	170	0	57	0	0	230.5	−4.0	−0.5	−8
Willow Glen	150	0	61	0	0	360	−5.9	−2	−10
Hamilton Avenue (Campbell)	180	0	56	0	0	267	−4.8	−1	−10
Winchester and Prune Ridge	125	1	60	0	0.5	249	−4.1	+0.5	−12
Moreland	190	0	59	2	0	250	−4.1	0	−8
Cupertino	265	7	40	11	14	109	−1.6	+7	−8
Loyola	210	11	37	12	12.5	83.5	−1.2	+2	−7.5
Sunnyvale	120	2	57	2	4	246	−4.0	+3	−13
Pomeroy	100	1	60	0	1	301	−4.9	+1	−9.5
Midway (1922)	25	2	24	1	7	76	−2.6	+4	−6
Mountain View Junction (1923 only)	130	1	26	2	2	130	−4.4	+2	−12
Vasona Junction (1923 only)	285	2	20	7	2	53	−1.8	+1	−7
Pioneer (1923)	240	3	25	1	17	96	−2.7	+8	−7
South Coyote (1923 only)	280	3	25	0	2	125	−4.5	+1	−10
Joseph Ranch (part 1923)	600	15	4	0	66	15	+2.7	+10	−6
Santa Clara	80	1	46	0	3	113	−2.3	+3	−8
Los Gatos	475	40	15	4	121	30	+1.5	+11	−4
Mountain View (deciduous fruit station)	90	1	56	2	3	171	−2.8	+3	−12

TABLE 3.—*Probable numbers of days in 10 years with certain minimum temperatures, or lower, at certain stations in the Santa Clara Valley, Calif., during certain periods in spring*

Stations and periods	Probable numbers of times in 10 years the following temperatures will be equaled or exceeded										
	25°	26°	27°	28°	29°	30°	31°	32°	33°	34°	35°
Berryessa:											
First half March			1	3	7	12	18	24	31	39	49
Second half March				1	2	5	9	14	20	26	32
First half April					1	3	5	9	15	21	27
Second half April					1	2	4	6	9	12	17
First half May								1	2	6	11
Toyon Avenue:											
First half March						1	3	7	12	18	24
Second half March							1	2	5	10	15
First half April								1	3	5	9
Second half April								1	2	4	6
First half May											1
Evergreen:											
First half March			1	4	8	13	19	26	33	41	51
Second half March				1	3	6	10	15	21	27	33
First half April					1	3	6	10	16	22	29
Second half April					1	2	4	6	9	13	19
First half May								1	3	7	12
McKinley:											
First half March		1	3	7	12	18	24	33	42	54	69
Second half March			1	2	5	9	15	21	28	35	49
First half April				1	3	5	9	16	23	31	42
Second half April				1	2	4	6	9	14	21	35
First half May							1	3	7	15	27
Oak Grove:											
First half March			1	5	11	17	24	32	40	49	58
Second half March				1	4	9	14	20	26	32	39
First half April					2	5	9	15	21	27	34
Second half April					2	4	6	9	12	17	24
First half May							1	2	6	11	18
Valley View and Hamilton Avenue:											
First half March			1	3	8	14	22	31	41	52	64
Second half March				1	3	7	12	19	27	35	45
First half April					1	3	7	14	22	30	39
Second half April					1	2	5	9	13	20	30
First half May							1	2	6	14	23
Willow Glen:											
First half March	1	3	7	14	22	31	43	55	69	79	89
Second half March		1	2	7	12	20	28	36	49	65	78
First half April			1	3	7	15	23	32	42	52	62
Second half April			1	2	5	9	14	21	36	47	57
First half May					1	2	7	15	27	36	48
Winchester (1922) and Prune Ridge (1923):											
First half March			1	5	10	15	22	30	39	49	58
Second half March				1	4	8	12	19	26	32	39
First half April					2	4	7	14	21	27	34
Second half April					1	3	5	8	12	17	24
First half May							1	3	6	11	18
Moreland:											
First half March			1	5	10	17	24	31	39	49	58
Second half March				1	4	9	14	20	25	32	39
First half April					2	5	9	15	21	27	34
Second half April					1	4	6	9	12	17	24
First half May							1	2	6	11	18
Cupertino:											
First half March						1	4	10	17	24	31
Second half March							1	4	9	14	20
First half April								2	5	9	15
Second half April								1	4	6	9
First half May										1	2
Loyola:											
First half March							2	6	11	17	24
Second half March								2	4	9	14
First half April								1	2	5	9
Second half April									2	4	6
First half May											1
Sunnyvale:											
First half March			1	3	7	11	18	27	36	49	62
Second half March					2	5	10	17	24	32	43
First half April					1	3	5	11	18	27	37
Second half April					1	2	4	6	11	17	29
First half May								1	4	11	21
Pomeroy:											
First half March			2	5	11	17	24	32	43	56	69
Second half March				2	4	9	14	20	28	36	49
First half April					2	5	9	15	23	32	42
Second half April					2	4	6	9	14	21	35
First half May							1	2	7	15	27
Midway (1922 only):											
1st half March				1	3	7	12	18	24	32	39
Second half March					1	2	5	9	14	20	25
First half April						1	2	5	9	15	21
Second half April							2	4	6	9	12
First half May									1	2	6
Mountain View Junction (1923 only):											
First half March		1	4	10	17	24	31	39	48	58	69
Second half March			1	4	9	14	20	26	32	39	50
First half April				2	5	9	15	21	27	34	42
Second half April				1	4	6	9	12	17	25	35
First half May						1	2	6	11	18	27
Vasona Junction (1923 only):											
First half March					1	3	7	12	18	24	31
Second half March						1	2	5	9	14	20
First half April							1	3	5	9	15
Second half April								2	4	6	9
First half May										1	2
Pioneer (1923 only):											
First half March			1	3	7	12	19	27	36	48	60
Second half March				1	2	5	10	17	23	32	41
First half April					1	3	6	11	18	27	36
Second half April					1	2	4	7	11	17	26
First half May								1	4	11	20
South Coyote (1923 only):											
First half March				1	3	7	14	22	31	43	55
Second half March					1	2	6	13	20	28	36
First half April						1	3	7	15	23	31
Second half April						1	2	5	9	14	21
First half May									2	7	15
Joseph Ranch (March 1923 only):											
First half March											1
Second half March											0
Santa Clara:											
First half March				1	3	7	12	18	24	31	39
Second half March					1	2	5	9	14	20	26
First half April						1	3	5	9	15	21
Second half April						1	2	4	6	9	12
First half May									1	2	6
Mountain View (decided fruit station):											
First half March				1	3	7	13	20	28	38	49
Second half March					1	2	6	11	18	25	32
First half April						1	3	6	12	19	27
Second half April						1	2	4	7	11	17
First half May									1	5	11
Los Gatos:											
First half March									1	3	7
Second half March										1	2
First half April											1
Second half April											1
First half May											0

634.9.43 : 551 : 515

FORESTS FIRES AND STORM MOVEMENT[1]

By E. F. MCCARTHY, Silviculturist

[Appalachian Forest Experiment Station, U. S. Forest Service]

A study of weather in relation to forest-fire hazard was carried on during the usual fire season from October 15 to November 30, 1923. Weather data were obtained from the United States Weather Bureau station at Asheville, N. C., and fire records from the national forests of western North Carolina and eastern Tennessee, and from the district fire warden for the mountain district of North Carolina.

While the purpose was to determine the feasibility of predicting periods of fire hazard two or more days in advance, the data collected have made possible the comparison of the current season with the fall season of 1922, for which records were obtained last year.[2]

In the fall of 1922 a season of severe forest fire hazard was experienced throughout the Southern Appalachians from the last week in October to about the end of November. The fire season of 1923 was of much shorter duration and of medium severity for about 15 days. A detailed discussion of these two seasons will make clear the value of weather information as a factor in fire protection.

Before entering a discussion of weather it should be known that fall fires in this region are fed largely by leaf litter of the current year and only minor fires can occur until the leaves are down in quantity and dry enough to create fuel for a fire.

In 1922 a dry period through September and early October was followed, beginning October 5, by heavy

[1] Presented at the meeting of the Society of American Foresters, Baltimore, Md., Dec. 28, 1923.

[2] "Forest Fire Weather in the Southern Appalachians," MO. WEATHER REV., April, 1923, 51; 182–185.